THE NUTRITIONAL AND THERAPEUTIC IMPORTANCE OF
AVENA SATIVA - AN OVERVIEW

Ali Esmail Al-Snafi

Department of Pharmacology, College of Medicine, Thiqar University, Iraq.

ABSTRACT
Avena sativa is a rich source of protein, minerals, lipids, β-glucan, avenanthramides, indole alkaloid, flavonoids, triterpenoidsaponins, lipids and sterols. It exerted many pharmacological effects including antioxidant, anti-inflammatory, dermatological, immunomodulatory, antidiabetic, gastrointestinal, hypolipidemic, neurological, cardiovascular and many other biological activities. This paper will highlight its chemical constituents and potential therapeutic effect.

Key words: Avena sativa, Oat, Pharmacology, Chemical constituents.

INTRODUCTION
For the past decades, there has been an increasing interest in the investigation of different extract obtained from plants for nutritional and therapeutic purposes. Avena sativa is a rich source of protein, minerals, lipids, β-glucan, avenanthramides, indole alkaloid, flavonoids, triterpenoidsaponins, lipids and sterols. It exerted many pharmacological effects including antioxidant, anti-inflammatory, dermatological, immunomodulatory, antidiabetic, gastrointestinal, hypolipidemic, neurological, cardiovascular and many other biological activities.

Synonym
Avena sativa var. abyssinica (Hochst.) Körn.
Avena sativa var. barbata (Pott ex Link) Fiori, Avena sativa var. biaristata Hack. Ex Trab., ena sativa var. biaristata Alef., Avena sativa var. brachytricha (Thell.) Tzvelev, Avena ativa var. braunii Körn., Avena sativa var. brevis (Roth) Fiori, Avena sativa subsp. byzantina (K. Koch) Romero Zarco, Avena sativa subsp. chinensis (Fisch. ex Roem. &Schult.) Holub, Avena sativa var. chinensis Döll, Avena sativa var. chinensis Vil., Avena sativa var. Cinerea Körn., Avena sativa var. cinerea (Körn.) Vascon., Avena sativa subsp. Contracta (Neirl.) Celak., Avena sativa var. contracta Neirl., Avena sativa subsp. fatua (L.) Fiori, Avena sativa var. diffusa Neirl., Avena sativa var. fatua (L) Fiori, Avena sativa var. fatua (L) Fiori, Avena sativa subsp. fatua (L) Thell., Avena sativa var. flavescens (Peterm.) Soö., Avena sativa var. fuscoatra (Peterm.) Soö, Avena sativa var. glaberrima (Thell.) Maire & Weiller, Avena sativa var. Glaberrima (Thell.) Parodi, Avena sativa var. hildebrandtii Körn., Avena sativa var. Hispanica (Ard.) Steud., Avena sativa var. kazanensis Vavilov, Avena sativa var. Leiantha (Malzev) E. Moreen, Avena sativa var. ludoviciana (Durieu) Fiori, Avena sativa subsp. macrantha (Hack.) Rocha Afonso, Avena sativa var. macrantha Hack.,

Corresponding Author: Ali Esmail Al-Snafi Email: aboahmad61@yahoo.com

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Common names
Arabic: Shofan, doser, qurtman, khafour, khertal; English: Oat, cereal oat and common oat; French: Oats and avoine; German: Hafer; Italian and Spanish: Avena [1-4].

Taxonomic Classification
Kingdom: Plantae
Subkingdom: Tracheobionta
Superdivision: Spermatophyta
Division: Magnoliophyta
Class: Liliopsida
Subclass: Commelinidae
Order: Cyperales
Family: Poaceae
Genus: Avena
Species: Avena sativa[5-6].

Description
It is erect tufted annual grass, to 1.2 m tall; culms smooth or scabrous beneath the panicle; leaves 15–30 cm long, 0.6–1.2 cm wide, sheaths long and loose; panicle terminal, 15–30 cm long; spikelets usually 2-flowered, to 2.5 cm long, slender-pedicelled; glumes, several-nerved; lemma glabrous, teeth acute, dorsal awn absent or 1 to a floret, short; kernel 0.6–0.8 cm long, narrow, with nearly parallel sides, hairy, grooved lengthwise on the face, tightly enclosed (in inrolled lemma which also covers the pala on the front [7].

Distribution
Oat has been cultivated for over 5000 years. Oats are the fourth most important crop worldwide. Oat producer’s countries (Million metric tons) were: Russia 5.1, Canada 3.3, United States 1.7, Poland 1.3, Finland 1.2, Australia 1.1, Germany 1.0, Belarus 0.8, China 0.8, and Ukraine 0.8 - 24.6 [2].

Traditional uses
It was used as cardiac and nerve tonic, for spermatorrhoea, palpitation, sleeplessness, antispasmodic, for diarrhoea, dysentery, and colitis. It was also used as thymoleptic, antidepressant and externally as emollient [8].

Part used
Fresh milky seed was used for medicine. The mature seed is eaten as food.

Chemical constituents
Whole oat groat contained high amounts of valuable nutrients such as soluble fibers, proteins, unsaturated fatty acids, vitamins, minerals, and other phytochemicals. Each 100g of oat groat contained 17.1% protein, 67.9% carbohydrates, 8.6% fat, 15-22% dietary fiber, 10.4% β-glucan, 1.3 mg niacin, 171 mg magnesium, 0.17 mg copper, 441 mg potassium and α-tocopherol less than 0.5 mg [9-11]. Silicon dioxide (2%) occurs in the leaves and in the straw in soluble form as esters of silicic acid. Oat straw contained a high iron (39 mg/kg dry weight), manganese (8.5 mg) and zinc (19.2 mg) [8]. However, Avena sativa seeds were also rich in body-building nutrients including silicon, manganese, zinc, calcium, phosphorus and vitamins A, B1, B2 and E. [12].

Oat-β-glucan was a soluble fiber and viscous polysaccharide made up of units of the monosaccharide D-glucose. The bonds between the D-glucose and D-glucopyranosyl units are β1, 3 linkages or β 1, 4 linkages. The (1→3)-linkages break up the uniform structure of the βD-glucan molecule and make it soluble and flexible. In comparison, the oat indigestible polysaccharide cellulose is insoluble. The reason for insolubility is that cellulose consists only of (1→4)-β-D-linkages. The percentages of β-glucan in the various whole oat products are: oat bran, greater than 5.5% and up to 23.0%, rolled oats, about 4%, and whole oat flour about 4% [13].
Soluble oligo- and polysaccharides including saccharose, kestose, neokestose, bifurcose, beta- glucans, galactoarabinoxylans, were isolated from *Avena sativa*. It also contained silicic acid, steroid saponins (avenacoside A and B), unusual amino acids (avenic acid A and B), sterols (beta-sitosterol, delta-5-avenasterol), fatty oil and flavonoids [14].

Oat contained 196.1 μg/g polyphenols, 83.5 mg/100g anthocyanins, 17.7 mg /100g flavonoids and 34.6% β-Carotene [9]. Several classes of compounds with antioxidant activity have been identified in oats (*Avena sativa*), including vitamin E, flavonoids, and nonflavonoid phenolic acids [15].

Flavonoids isolated from oat plants (leaves, stems, inflorescences) were included apigenin type flavones: C-glycosyl-apigenins, isovitexin and its 2″-O-arabinoside, 2″-O-glycosides of vitexin and di-C-glycosyl-apigenin; luteolin type: 6-C-glucoyl-luteolin (isoorientin), its 2″-O-glycosides, isoorientin-7-O-glucoside and isosorbin, 6-C-glucoyl-chrysoeriol and tricin type flavones: appear both as free aglycone and as tricin-4″: and/or -7-O-glycosides [14,16].

Three Avenanthramides compounds were isolated from *Avena sativa* seeds. Spectroscopic analyses suggested that they were amides of 4,5-dihydroxyanthranilic acid with caffeic, p-coumaric, and ferulic acids, respectively. These compounds showed stronger 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical-scavenging activity than the corresponding avenanthramides with 5-hydroxyanthranilic acid, indicating the involvement of 4,5-dihydroxyanthranilic acid moiety in the scavenging of DPPH radicals [17].

The antioxidant activities from whole oat groats of seven common varieties were evaluated. All oat varieties had very similar oxygen radical absorption capacity compared with other whole grains. Avenanthramide levels did not correlate with the observed antioxidant activities [20].

The protective effect of oat bran extract was evaluated on human dermal fibroblast injury induced by hydrogen peroxide (H₂O₂). Assays for 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging activity indicate that oat peptide-rich extract has a direct and concentration-dependent antioxidant activity. 3-(4,5-Dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide (MTT) colorimetric assay and the TdT-mediated digoxigenin-dUTP nick-end labeling (TUNEL) assay for apoptosis showed that administration of H₂O₂ in human dermal fibroblasts caused cell damage and apoptosis. Pre-incubation of human dermal fibroblasts with the oat for 24 h markedly inhibited human dermal fibroblast injury induced by H₂O₂, but application of oat peptides with H₂O₂ at same time did not. Pre-treatment of human dermal fibroblasts with oat significantly reversed the H₂O₂-induced decrease of superoxide dismutase (SOD) and the inhibition of malondialdehyde (MDA). The results demonstrate that oat peptides possess antioxidant activity and were effective against H₂O₂-induced human dermal fibroblast injury by the enhancing activity of SOD and decreasing MDA level. The results suggest that oat bran have the potential to prevent aging-related skin injury [21].

The efficiency of oats oil (6 g per kg bw) to alleviate oxidative damage of testis induced by deltamethrin (DEL), which is a pyrethroid pesticide that exerts a wide range of effects on non-targeted organisms, was studied. Exposure to deltamethrin at a dose of 5 mg per kg bw per day caused oxidative stress in testis, proven...
by a decrease in the epididymal sperm count and motility, an increase in the number of abnormal morphologies in spermatozoa and a significant increase of lipid peroxidation (LP) in the testis when compared to control animals. Co-administration of oats oil to the DEL-treated mice ameliorated the testicular biochemical parameters as well as the histological impairments in testis [22].

**Hyolipidemic effects**

Oat β-glucan exerted cholesterol-lowering properties. The consumption of oat meal and oat bran reduced total plasma cholesterol and LDL-cholesterol levels. This effect attributed to β-glucan, it interfered with the reabsorption of bile acid in the gut and reduces cholesterol levels. The oat bran has been found to be the fiber source that significantly lowered total and low density-lipoprotein cholesterol levels in mild hypercholesteroleemics [23].

C57BL/6 NCrI mice responded to oat bran with 19 ± 1 % (P < 0.001) lower plasma cholesterol, 40 ± 5% (P < 0.01) higher excretion of bile acids and increased expression of the bile acid-producing hepatic enzymes CYP7A1 and CYP8B1, but none of these effects were found in C57BL/6JBomTac mice. However, on control diet, C57BL/6JBomTac had tenfold higher expression of CYP7A1 and levels of hepatic cholesterol esters than C57BL/6NcrI mice [24].

The United States Food and Drug Administration (FDA) approved a health claim for β-glucan soluble fiber from oats for reducing plasma cholesterol levels and risk of heart disease in 1997. Similarly, in 2004 the United Kingdom Joint Health Claims Initiative (JHCI) allowed a cholesterol-lowering health claim for oat β-glucan. Studies conducted during the past 13 years support the suggestion that intake of oat β-glucan at daily doses, of at least 3 g, reduced plasma total and low-density lipoprotein (LDL) cholesterol levels by 5-10% in normcholesterolemic or hypercholesterolemic subjects. Studies also showed that oat consumption is associated with 5% reductions in total cholesterol levels [25].

The effect of oat consumption on serum lipid profiles was studied in Thai hypercholesterolemic adults. Following daily oat consumption, total cholesterol and LDL-cholesterol levels were significantly lower than baseline levels and lower than the levels observed with rice consumption. Oat consumption reduced total cholesterol by 5% and LDL-cholesterol by 10% from baseline levels. In addition, mean and percent changes were significantly different from the levels after consuming rice porridge (p < 0.05) [26].

**Cardiovascular effect**

In addition to its cholesterol lowering effect, it improved the blood pressure when consumed with vitamin C, improved endothelial function and exerted antihypertensive effects [27].

Katz et al., reported that a single serving of oatmeal opposed the disturbances in endothelial function observed after the consumption of a high fat meal [27].

In overweight patients, beta glucan from oats has been shown to decrease hypertension. Avenanthramide is an oat polyphenol that has been shown to enhance production of nitric oxide, a potent vasodilator, and to inhibit thickening of vascular smooth muscle. Both actions are preventative for developing of atherosclerosis[28-29].

**Anti-obesity effect**

A clinical trial was carried out to confirm the anti-obesity effect of oat. Subjects with BMI ≥27 and aged 18-65, were randomly divided into a control and an oat-treated group, taking a placebo or beta glucan-containing oat cereal, respectively, for 12 weeks. The result showed that consumption of oat reduced body weight, BMI, body fat and the waist-to-hip ratio. Profiles of hepatic function, including AST and ALT showed decrements in patients with oat consumption. Nevertheless, anatomic changes were not observed by ultrasonic image analysis. Ingestion of oat was well tolerated and there was no adverse effect during the trial [30].

To explored the dose-dependent effect of oat cereal β-glucan on improving metabolic indexes of obesity mice, C57-B1 mice were randomized to chow diet (N) group and high fat diet group and other three doses of oat β-glucan groups (low β-glucan, medium β-glucan, and high β-glucan). Energy intake, glucose, lipids, and appetite related hormones were tested. Dose-dependent relation was observed on oat β-glucan doses and body weight change, average energy intake, total cholesterol, HDL cholesterol, plasma neural peptide Y, arcuate neural peptide Y mRNA, and arcuate neural peptide Y receptor 2 mRNA level. Oat β-glucan helped to increase plasma peptide Y-Y and intestine peptide Y-Y expression in obesity mice [31].

**Antidiabetic effect**

The treatment with *Avenasativa* increased insulin activity and improved sensitivity for normalizing blood glucose level and reduce glucose production by the liver [32]. The glycaemic and insulinaemic response to oat bread, oat bread with lingonberryfibre, oat-buckwheat bread and buckwheat porridge were tested in a small-scale clinical study [KHSHP E514/09]. Nine healthy volunteers consumed test foods after overnight fasting. From samples taken at seven time points during 120 min. The mean glycaemic and C-peptide indexes (C-peps) were 32 and 100 for oat bread, 47 and 119 for oat-lingonberryfibre
baked, 58 and 105 for oat-buckwheat bread and 71 and 77 for buckwheat porridge [33].

Oat and barley foods have been shown to reduce human glycemic response, compared to similar wheat foods or a glucose control. Regression analysis on 119 treatments indicated that change in glycemic response (expressed as incremental area under the post-prandial blood-glucose curve) was greater for intact grains than for processed foods. For processed foods, glycemic response was more strongly related to the β-glucan dose alone (r(2)=0.48, P<0.0001) than to the ratio of β-glucan to the available carbohydrate (r(2)=0.25, P<0.0001). For processed foods containing 4 g of β-glucan, the linear model predicted a decrease in glycemic response of 27 ± 3 mmol/min/L. Thus, intact grains as well as a variety of processed oat and barley foods containing at least 4 g of β-glucan and 30-80 g available carbohydrate can significantly reduce post-prandial blood glucose [34].

**Antimicrobial effects**

The 70% ethanolic extract of the *Avena sativa* exerted antibacterial activity against gram positive bacteria (*Staphylococcus aureus*), and gram negative bacteria (*E. coli, Proteus vulgaris, Pseudomonas aerugiuosa, and Klebsiella*). The extract also exerted antifungal activity against *A. niger*, and *Candida* [32]. A protein fraction rich in Cys/Gly residues extracted from oat (*Avena sativa*) seeds possessed weak to moderate antifungal properties to some fungal strains [18].

**Dermatological effects**

Oatmeal preparations were effective on a variety of dermatologic inflammatory diseases such as pruritus, atopic dermatitis, acneiform eruptions, and viral infections. Additionally, oatmeal plays a role in cosmetics preparations and skin protection against ultraviolet rays [35].

The dried seeds was used to make a decoction to relieve the symptoms of eczema, the soothing emollient activity of the seeds decreased itching and nourished the skin. Oat colloidal extract containing avenanthramides has also proved to have antihistamine and anti-irritation activity [36-38].

MTT, Dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide colorimetric assay and the TdT-mediated digoxigenin-dUTP nick-end labeling (TUNEL) assay for apoptosis showed that administration of H_2O_2 in human dermal fibroblasts caused cell damage and apoptosis. Pre-incubation of human dermal fibroblasts with the oat for 24 h markedly inhibited human dermal fibroblast injury induced by H_2O_2. The results suggest that oat bran have the potential to prevent aging-related skin injury [39].

Avenanthramides have been reported to exhibit anti-inflammatory activity in the skin. Avenanthramides at concentrations as low as 1 parts per billion inhibited the degradation of inhibitor of nuclear factor kappa B-alpha (IkappaB-alpha) in keratinocytes which correlated with decreased phosphorylation of p65 subunit of nuclear factor kappa B (NF-kappaB). Furthermore, cells treated with avenanthramides showed a significant inhibition of tumor necrosis factor-alpha (TNF-alpha) induced NF-kappaB luciferase activity and subsequent reduction of interleukin-8 (IL-8) release [38].

**Central nervous effects**

An extract of wild green oat (*Avenasativa*) was tested in rats for its behavioural effects after chronic oral administration via extract-admixed food. Rats received 10 and 100 g/kg extract-admixed food showed slight decreased food and fluid intake in the high dose group, with no side effects observed during the treatment. The low dose led to an improvement of active stress response, an enhancement of shock avoidance learning and an increased synchrony in social behavior [40].

Dietary oat β-glucan enhanced the endurance capacity of rats and facilitated their recovery from stress and fatigue. Sparsgue-Dawley rats, fed with/without oat β-glucan 312.5 mg/ kg/day for 7 weeks, were subjected to run on a treadmill system to make them exhausted. All rats were immediately sacrificed after prolonged exercise, and the major metabolic substrates were measured in serum and liver. Feeding dietary oat β-glucan to rats significantly reduced the body weight and increased the maximum running time compared with normal control (P<0.05). Furthermore, dietary oat β-glucan decreased the levels of blood urea nitrogen, lactate acid, and creatine kinase activity in serum, and increased the levels of non-esterified fatty acids, lactic dehydrogenase activity in serum, and the content of liver glycogen [41].

*Avenasativa* improved overall mental fitness and supported cognitive performance in stressful situations. *Avenasativa* has been shown to positively affect the activity of brain enzymes closely related to mental health and cognitive function in *vitro*. Additionally, preclinical and clinical studies have confirmed that *Avena sativa* specifically interacted with brain structures and neurotransmitters implicated in cognition, memory and motivation. *Avena sativa* boasted a dual activity profile on monoaminoxidase-B (MAO-B) and phosphodiesterase 4 (PDE4) thus displayed in its ability to meditate a strengthening and balancing effect on the brain and mind [13].

The dried seeds and fresh plant exerted antidepressant activity, and it was useful where lowered mood is associated with anxiety and nervous exhaustion, especially during menopause. The fresh plant is a tonic remedy for all types of nervous debility, and can help to improve sleep duration and quality where the person is literally too tired to sleep [12]. A dose of 1600 mg of oat herb extract acutely improve attention and concentration and the ability to maintain task focus in older adults with
differing levels of cognitive status [42]. However, the aqueous extract prepared from the tincture did not affect the seizure threshold to bemegride or nicotine or the sleeping time induced by barbitone sodium [14].

For smokers and opium addicts

The biological effects of *Avena sativa* have been investigated in laboratory animals following a report that tincture of *Avena sativa* reduced the craving for cigarettes in man. On the other hand, when the tincture evaporated to dryness, re-constituted in an equal volume of water and administered by stomach tube or intraperitoneal injection, it antagonized the antinociceptive effect of morphine in two separate test (hot-plate and tail flick). Compared with animals made dependent on morphine, mice pretreated with repeated injections of morphine plus extract passed a smaller number of stools and tended to jump less after administration of nalorphine [43].

An alcoholic extract of green oats was tried on opium human addicts. Six chronic opium addicts gave up opium completely, two reduced their intake and two showed no change following regular use of 2 ml three times daily. A significant diminishment of the number of cigarettes used by habitual tobacco smokers resulted from using 1 ml (four times daily) of fresh *Avena sativa* alcoholic extract of mature plants [8].

The pressor response to intravenously administered nicotine in urethane-anaesthetized rats was also antagonized by prior administration of *Avena sativa* [14]. An alcoholic extract of common oats (*Avena sativa*) has been reported to reduce both the craving for, and the number of, cigarettes smoked per day [44]. Hundred non-hospitalized smokers with an average consumption of 20 cigarettes per day were treated with an alcoholic extract of *Avena sativa*. There was difference of disaccustoming between light and heavy smokers. The rate of disaccustoming was higher for light smokers than for smokers with a high consumption of cigarettes [45].

Gastrointestinal effects

Two broiler experiments with almost identical basal diets were conducted to investigate the effect of dietary oat hulls, access to litter and the antimicrobial compound narasin on gizzard erosion and ulceration syndrome (GEU). The effects on particle size of duodenal digesta, ileal starch concentration, caecal *Clostridium perfringens* counts, necrotic enteritis and production performance were also examined. Oat hulls reduced GEU severity and starch levels in the ileum in both experiments. Access to litter reduced GEU scores when oat hulls were included in the feed. Access to litter also improved feed efficiency and reduced *C. perfringens* counts. Oat hulls were associated with improved feed efficiency in Experiment 1 and impaired feed efficiency in Experiment 2. The inconsistent effect of oat hulls on production performance appeared to be related to an association between oat hulls and high *C. perfringens* counts in Experiment 2; an association that was absent in Experiment 1. In general, oat hulls interacted with litter access and narasin in exerting a positive effect on gizzard health. However, the association between oat hulls and necrotic enteritis detected in Experiment 2 suggests that the positive effect of oat hulls on GEU occasionally may be outweighed by a negative effect on gut health [46].

The potential inhibitory effects of oat β-glucan (1%, 5%, or 10%) added to a specific pathogen-free diet was investigated in Nonalcoholic steatohepatitis (NASH) induced in mice by intraperitoneally injected lipopolysaccharide (LPS). Intraperitoneal injection of LPS for 6 weeks increased serum LPS levels; decreased serum glucagon-like peptide-2 levels; triggered abnormal aminotransferase activity, glucose intolerance, and insulin resistance; and increased hepatic proinflammatory cytokines (tumor necrosis factor-α, interleukin-6, interleukin-1β), triglyceride, and malonyldialdehyde levels; but reduced hepatic superoxide dismutase activity. Histologic evaluation revealed evidence of hepatic steatosis, inflammation, and mild necrosis in LPS-treated mice. Dietary supplementation of oat β-glucan prevented most of the LPS-induced metabolic disorders, and improved hepatic steatosis and inflammation, although a dose-dependent effect was not observed [47].

Three major oat components, β-glucan, starch, and protein, and their interactions were evaluated for the impact on viscosity of heated oat slurries and *in vitro* bile acid binding. Oat flour from the experimental oat line "N979" (7.45% β-glucan) was mixed with water and heated to make oat slurry. Heated oat slurries were treated with α-amylase, lichenase, and/or proteinase to remove starch, β-glucan, and/or protein. Oat slurries treated with lichenase or lichenase combined with α-amylase and/or proteinase reduced the molecular weight of β-glucan. Heat and enzymatic treatment of oat slurries reduced the peak and final viscosities compared with the control. The control bound the least amount of bile acids (p<0.05); heating of oat flour improved the binding. Heated oat slurries treated with lichenase or lichenase combined with α-amylase and/or proteinase bound the least amount of bile acid, indicating the contribution of β-glucan to binding. Oat slurries treated with proteinase or proteinase and α-amylase together improved the bile acid binding, indicating the possible contribution of protein to binding [48].

Oats have been shown to absorb intestinal toxins and increase excretion of intestinal toxins. The combination of taurine and oat were investigate on endotoxin release in a rat liver ischemia/reperfusion model. The results showed that the combination of taurine (300mg/kg/day) and oat fiber (15g/kg/day) significantly reduced endotoxin levels in the portal vein by 36.3% when compared to the control group (0.168±0.035EU/ml in the treatment group vs 0.264±0.058EU/ml in the control
group, P<0.01). The treatment by taurine and oat fiber induced 21.5% and 18.4% reduction in endotoxin levels respectively, when compared to the control group (P<0.05) [49]. Oat bran has been proposed as a dietary treatment for ulcerative colitis and has been shown to increase endogenous butyrate production and provide symptomatic relief of abdominal pain [50].

**Immunological and anti-inflammatory effects**

β-glucan helped neutrophils to reach the site of infection more rapidly and enhanced their ability to eliminate the bacteria [51].

The different immunological aspects of β-glucans derived from different food sources (oat, barley and shiitake) was examined on phorbolmyristate acetate (PMA)-differentiated THP-1 macrophages. Inflammation-related gene expression kinetics (IL-1β, IL-8, nuclear factor kappa B [NF-kB] and IL-10) were evaluated after 3, 6 and 24 h of stimulation with 100 µg/ml β-glucan. All tested β-glucans were mildly up-regulated the observed inflammation-related genes with differential gene expression patterns. Similar gene expression kinetics, but different fold induction values, was found for the crude β-glucan extracts and their corresponding commercial forms. Pre-incubation of THP-1 macrophages with β-glucans prior to lipopolysaccharide (LPS) exposure decreased the induction of inflammation-related genes compared to LPS treatment. No production of nitric oxide (NO) and hydrogen peroxide was detected in β-glucan stimulated THP-1 macrophages. Phagocytic activity was not differ after stimulation by β-glucan samples. Based on these in vitro analyses, β-glucans have varying levels of immunomodulating properties, which are likely related to structure, molecular weight and compositional characteristic of β-glucan [52].

The anti-inflammatory activities from whole oat groats of seven common varieties were evaluated. Oat variety CDC Dancer inhibited tumor necrosis factor-α induced nuclear factor-kappa B activation by 27.5% at 2 mg/ml, whereas, variety Deiter showed 13.7% inhibition at a comparable dose. Avenanthramide levels did not correlate with the observed anti-inflammatory activities[20].

Avenanthramides have been reported to exhibit anti-inflammatory activity on the skin. Keratinocytes treated with avenanthramides showed a significant inhibition of tumor necrosis factor-alpha (TNF-alpha) induced NF-kappa B luciferase activity and subsequent reduction of interleukin-8 (IL-8) release [38].

**Other pharmacological effects**

In an experimental study, oat straw stimulated the release of luteinizing hormone from the adenohypophysis of rats [8]. *Avenasativa* contained oestrone which has been shown to induce ovulation [53-55].

**Contraindications and side effects**

No health hazards or side effects are known in conjunction with the proper administration of designated therapeutic dosages. Oat bran products should be taken with large amounts of water to assure that the fiber is well dispersed in the bowel. It was contraindicated in patients with coeliac disease and intestinal obstruction. The side effects of the herb were included flatulence and anal irritation [14, 56].

**Dosage**

The herb was used in combination therapy, as a tea for internal use. To make a tea, 3 gm of the plant was boiled in 250 ml water, which was strained after cooling. The tea is taken repeatedly throughout the day and shortly before going to bed [14].

**CONCLUSION**

The paper reviewed *Avena sativa* for its nutritional and therapeutic potentials. It is a promising medicinal plant with wide range of pharmacological activities which could be utilized in several medical applications because of its effectiveness and safety.

**REFERENCES**

1. The plant list, a working list of all plant species, http://www.theplantlist.org/tpl/search?q=Avena sativa


12. Dr. Boxall’s Products containing Sceletium Tortuosum with *Avenasativa*.www.drboxalls.com


